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THE EARTHQUAKE DISASTER RISK BASED-CRITERIA OF TRANSFER OF DEVELOPMENT RIGHTS SENDING AND RECEIVING AREAS IN SEMBALUN DISTRICT OF EAST LOMBOK REGENCY, INDONESIA

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ABSTRACT
Sembalun district is one of the areas in East Lombok Regency which has high level of earthquake disaster vulnerability. The government has been so far issuing resettlement and relocation efforts, but these are considered less optimal because they do not pay attention to the balance of community's ownership rights and development rights. As a solution, the government of East Lombok Regency needs to formulate an instrument to control the use of space, one of which is through transfer of development rights (TDR). In order to optimize the policy, it is necessary to identify the criteria of TDR sending and receiving areas. The approach used in the research was descriptive qualitative with Delphi analysis. The findings suggest that the criteria of sending areas are those which are protected, being limited development, have high development demand, and have a level of damage caused by earthquake. The criteria for receiving areas consist of areas with medium-high density; excess carrying capacity and capacity; are directed towards the development of settlements and urban areas; adjacent to the existing built-up zone; have potential connection to public transport; have adequate utility infrastructure; and are potential areas in accordance with spatial plan.

KEY WORDS
Delphi analysis, earthquake, Sembalun District, conceptual model, transfer of development rights.

Indonesia is one of the countries with high vulnerability level to natural disasters (Hadi, et. al., 2019). Based on the data of *World Risk Report 2018,* Indonesia is at the 36th rank with risk index of 10.36 of 172 of the most natural hazard-prone countries in the world. This is because Indonesia is tectonically located where the three world tectonic plates meet (Eurasia, Indonesia-Australia, and Pacific). Volcanically, Indonesia has an active volcanic pathway known as Pacific Ring of Fire (Hermon, 2014).

Geographically, Indonesia is disaster-prone area because it is located on the pacific ring of fire (a row of Pacific volcanoes) which extends from the north islands of Sumatra-Java-Nusa Tenggara to North Sulawesi. Indonesia is also located at the junction of two of the world's tectonic plates and is influenced by three movements namely Sunda System Movement in the west, East Asian System Movement and the Australian Circlum Movement. The three movements are factors that cause Indonesia vulnerable to disasters. Indonesia is also located on three active tectonic plates (triple junction plate convergence) which are Indo-Austrian Plate, Eurasian Plate, and Pacific Plate. Thus, it is very prone to geological hazards such as earthquakes, volcanic eruptions, landslides, and tsunamis. The Indo-Australian Plate collides with the Eurasian Plate off the coasts of Sumatra, Java and Nusa Tenggara, and with the Pacific Plate in northern Papua and North Maluku.

This condition caused a large-scale earthquake on Lombok Island in 2018 to occur three times and was followed by hundreds of aftershocks. The first earthquake hit with magnitude of 6.4 on July 29, 2018 in East Lombok. Then, it was followed by large earthquake on Sunday, August 5, 2018 centered in North Lombok. The third earthquake struck with magnitude of 7.0 on Sunday, August 19, 2018, centered in East Lombok.

Earthquakes that hit Lombok Island is one of natural events with destructive power affecting many aspects both physical and non-physical. They cause physical damage such as destruction of houses, trees, loss of life and other valuable things. The non-physical impacts are fear, trauma, despair, and other psychological things. Thus, the losses caused by earthquakes are not only related to life and mental issues but are also related to the economy disruption of the affected communities.

The efforts that have been carried out so far to mitigate earthquake disasters include resettlement and relocation. Resettlement is defined as an activity of moving the people from a place to another, either individually or collectively. This is intended to clear land parcels which have not been inhabited and will be cultivated by a certain group of people. Relocation means to move people from one place to another. Relocation is done by concerning the people's daily activity and sustainability with all physical and non-physical conditions. However, in the new location, the residents continue to adapt according to the problems they face. Thus, it can be said that the two efforts are circular (repeated/cyclical) and are considered less optimal in dealing with the impact of the disasters.

Sembalun District is an area with high disaster vulnerability because it is located under Mount Rinjani. Therefore, efforts are needed to reduce disaster risk. One of which is through the integration of aspects of disaster risk reduction into development planning, including regional spatial plans. Focusing on the aspects of disaster risk reduction is a development investment that will have long term impact in reducing future loss due to disasters. Achieving the goal of disaster -responsive spatial planning can be done through the arrangement of development areas and spaces for the community to do their daily socio-economic activity.

LITERATURE REVIEW

A disaster is an incident that damages infrastructure or social structure which interfere community survival. Earthquakes are the shaking of the earth which is caused by collision between the earth's plates, active faults, volcanic activity, or rock collapse (*Permen PU No. 21 Tahun 2007*). The level of a disaster can be measured through its risks. The general formula used to calculate the risk value in AS/NZS 4360 (2004) is "Risk = Consequence x Likelihood".

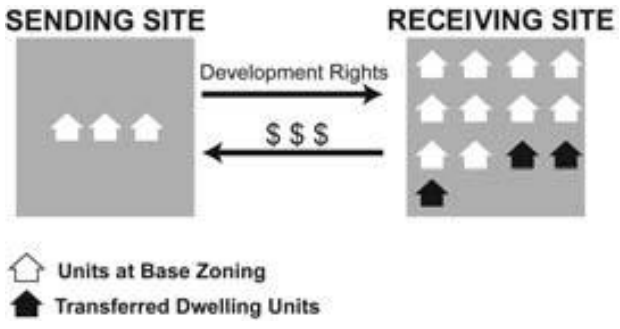

Figure 1 – TDR Sending and Receiving Site (Source: Doug Woodruff, 2012)

Disaster risk is the amount of loss or possible loss (of lives, victims, damage, and economic losses) caused by certain hazards in an area at a certain time. To reduce disaster hazards or threats and vulnerabilities which are potential to cause disasters, it is necessary to improve the capacity to prevent, reduce and cope with disaster risks.

Transfer of Development Rights (TDR) is a symbolic policy of *Gerakan Pertumbuhan Cerdas Kontemporer* (*contemporary smart growth movement*) (Klaus, 2020). It is one of land

use control tools that can be used as an alternative to overcome the problems. The principle of TDR is to allow the unused development rights of a site to be moved from areas which are considered less developed by the government to areas which are sought to develop (Guzle, 2020). From a public authority point of view, TDR would reduce a downzoning risk being seen as material appropriation which is opposed by landowners (Walls, et. al., 2007).

METHODS OF RESEARCH

The research used post positivism paradigm, selecting a mixed qualitative deductive approach. The location of the research was determined purposively based on the suitability of the area conditions with the research topic. The data was collected through direct observation at the site with institutional and literature surveys. The research sampling used non probability sampling technique namely purposive sampling. It was conducted by selecting the experts who understands the research topic. Analysis of stakeholders was performed to select 5 persons for in-depth interviews. The formulation of the factors influencing the success of TDR was obtained through the results of a systematic review and the results of a consensus statement on the Delphi analysis from the sources.

LITERATURE REVIEW

To get the research variable, analysis on the indicators of TDR sending and receiving areas was carried out based on the results of the previous studies. According to some sources (*Menghini, 2013; UU NO. 1 Tahun 2018; Permen ATR/BPN No. 16 Tahun 2018*), the indicators that influence the implementation of TDR can be synthesized as follows:

Table 1 – Theory synthesis regarding the indicators of TDR sending and receiving areas

No.	Area	Criteria
1.	Sending area	1. Areas whose resources or characteristics need to be protected/preserved
		2. Areas with restricted development
		3. Areas with low building density
		4. Can be located in areas with high development demand, but the carrying capacity and capacity are already limited
		5. The areas with minimum or without infrastructure
		6. Area without transportation connections
		7. An area that separates two or more adjacent protected areas
2.	Receiving area	1. Areas with medium-high density with adequate infrastructure support
		2. Still has the carrying capacity and capacity to receive additional space intensity
		3. Located in an area with high demand in development
		4. New areas to be residential and urban development
		5. Adjacent to the existing built-up zone
		6. Easy-to-use perceel (land lot) with low-cost infrastructure
		7. Perceel with potential connection to public transport

Source: The result of literature review, 2021.

The population in this study consisted of resource people who have influence and interest in the formulation of TDR policies in the research area. Thus, the detailed, accurate data and the information can be obtained. Based on the population, the samples were determined through non probability sampling technique namely purposive sampling. This was because the population was unknown. To find the purposive sampling, stakeholders' analysis was carried out as a tool to find respondents for the research subject.

The data collected were primary and secondary data. Primary data were gained using the five senses to get the facts without initially taking the samples. It was done to get the picture of the environmental condition and the changes that occurred. Primary data were collected through direct observation and in-depth interview. Secondary data were collected using the secondary survey techniques, both literature and institutional surveys to obtain formal documents. Secondary data was collected through institutional and media surveys.

Delphi analysis technique was adopted to explore the opinions of the stakeholders. It is a technique of qualitative data analysis which is done through questionnaires and interviews

with selected stakeholders. The technique has high level of validation because it involves experts in their fields and go through at least two iterations. Delphi is defined as a process in a group which involves interaction between researchers and a group of experts on a particular topic to gain a consensus through a systematic process (Rum, 2018).

RESULTS AND DISCUSSION

The formulation of the earthquake risk map in Sembalun District was generated based on the conceptual formula to calculate earthquake risk, namely the accumulation of hazard factors, vulnerability and the capacity of an area or community ability to cope with disaster. The relationship between threats, vulnerabilities, capacities, and risks is formulated as follows (*Perka BNPB* (Regulations of the Head of National Agency for Disaster Management) No. 2 of 2012):

$$\text{Disaster risks} = \frac{\text{threats } x \text{ vulnerability}}{\text{capacity}}$$

The term threat is mostly connected with danger (*UU No. 24 Tahun 2007 tentang Penanggulangan Bencana* (Law No. 24 of 2007 concerning Disaster Management)). The earthquake hazards map in Sembalun District was prepared using data of topography, intensity of earthquake shocks and history of earthquake disasters. Based on the analysis result map, it was known that Sembalun District is at a low, medium, to high level of earthquake hazard. Bilok Petung Village is one of the villages where the majority of the area is in moderate to high level of danger and only small part of it is in a low danger. The following is a map of the results of the earthquake hazard analysis in Sembalun District.

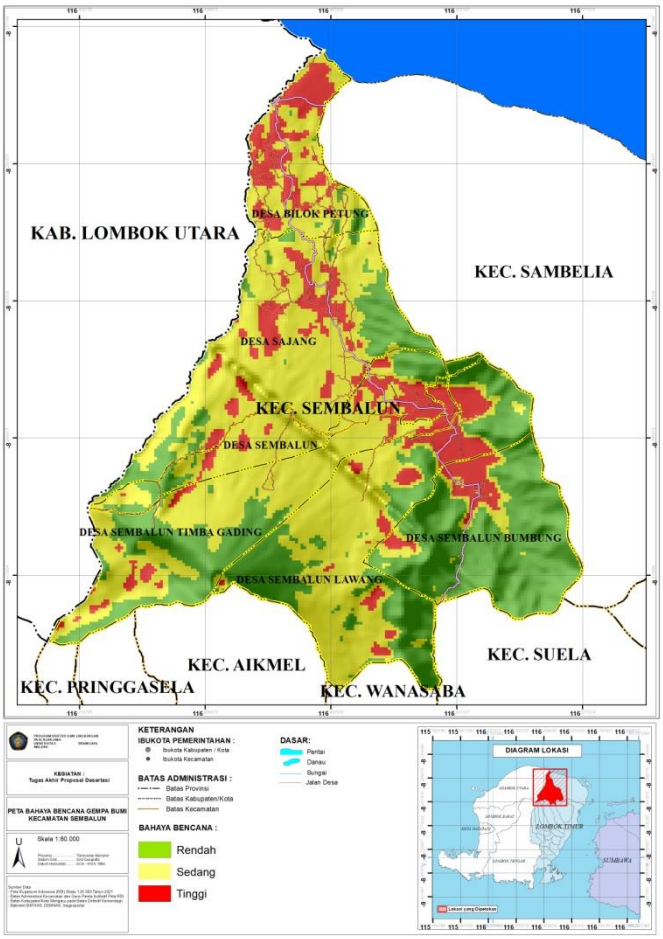

Figure 2 – Earthquake Hazard Map (Source: Analysis Result, 2021)

United Nation International Strategy for Disaster Reduction (UNISDR) classifies vulnerability into several aspects namely process of physical, social, economy, and environment (UNISDR, 2005b). In the research, the level of physical, social, economy and environment vulnerability aspects were determined using the method of AHP.

The aspects of social vulnerability were identified through several indicators, namely population density, sex ratio, ratio of vulnerable age groups, ratio of poverty, and ratio of vulnerable population. Based on the results of the analysis, the majority of social vulnerability aspect is at low level. The following is the extent of social vulnerability in Sembalun District:

Table 2 – Social Vulnerability in Sembalun District

Village	Area Social Vulnerability (Ha)			
	Low	Medium	High	Total
1. Sembalun	35.603	0	0	35.603
2. Sembalun Lawang	49.539	5.838	0	55.378
3. Sembalun Bumbung	31.436	7.718	0	39.154
4. Sembalun Timba Gading	43.111	695	0	43.806
5. Sajang	59.264	14.340	0	73.603
6. Bilok Petung	22.036	0	0	22.036

Source: Analysis Result, 2021.

Sajang Village is the village with the highest social vulnerability compared to other villages. Bilok Petung Village is the village with the lowest social vulnerability.

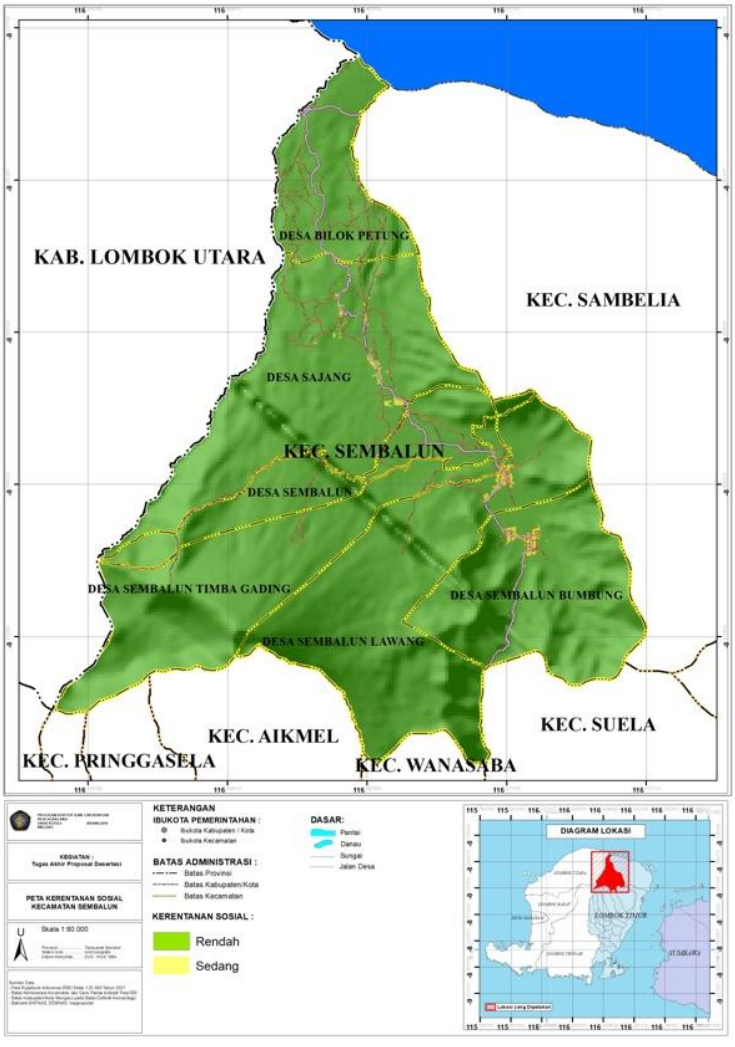

Figure 3 – Map of Social Vulnerability (Source: The Result of Analysis, 2021)

The aspect of physical vulnerability was identified through several indicators: the number of houses affected by the earthquake, the number of public facilities affected by the earthquake, and the number of critical facilities affected by the earthquake. Based on the results of the analysis, it was known that Sembalun District has low, medium, and high physical vulnerability. The assessment of physical vulnerability of Sembalun District is as follows:

Table 3 – Physical Vulnerability of Sembalun District

Village	Area Physical Vulnerability (Ha)			
	Low	medium	High	Total
1. Sembalun	2	1.635	2	1.639
2. Sembalun Lawang	0	1	4.426	4.427
3. Sembalun Bumbung	0	2.179	785	2.964
4. Sembalun Timba Gading	0	2	3.237	3.239
5. Sajang	3.075	1.311	0	4.386
6. Bilok Petung	1.718	0	0	1.718

Source: The result of analysis, 2021.

Sembalun Lawang and Sembalun Timba Gading are the villages with high physical vulnerability, while Sajang and Bilok Petung villages are those with low vulnerability.

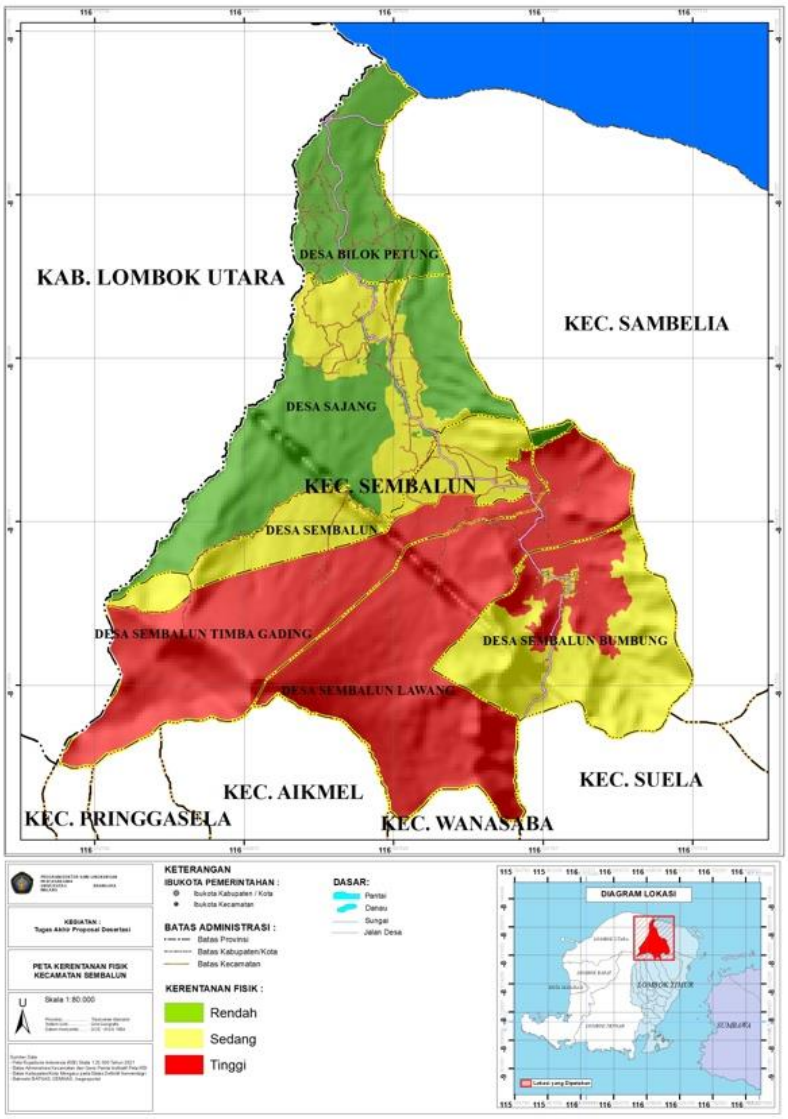

Figure 4 – Map of Physical Vulnerability (Source: Analysis Result, 2021)

The aspect of economy vulnerability was identified through two indicators: productive area and *PDRB* (gross regional domestic product). Based on the analysis, it was known that Sembalun District has low economy vulnerability. The assessment of economic vulnerability of Sembalun District is as follows:

Table 4 – Economy Vulnerability of Sembalun District

Village	Area Economic Vulnerability (Ha)			
	Low	Medium	High	Total
1. Sembalun	1.639	0	0	1.639
2. Sembalun Lawang	4.387	40	0	4.427
3. Sembalun Bumbung	2.911	0	53	2.964
4. Sembalun Timba Gading	3.239	0	0	3.239
5. Sajang	4.337	48	0	4.386
6. Bilok Petung	1.676	42	0	1.719

Source: Analysis Result, 2021.

There are areas with medium vulnerability at Sembalun Lawang, Sajang and Bilok villages with an area of 40 Ha, 48 Ha, and 42 Ha. Sembalun Bumbung Village, with an area of 53 Ha, has high economic vulnerability.

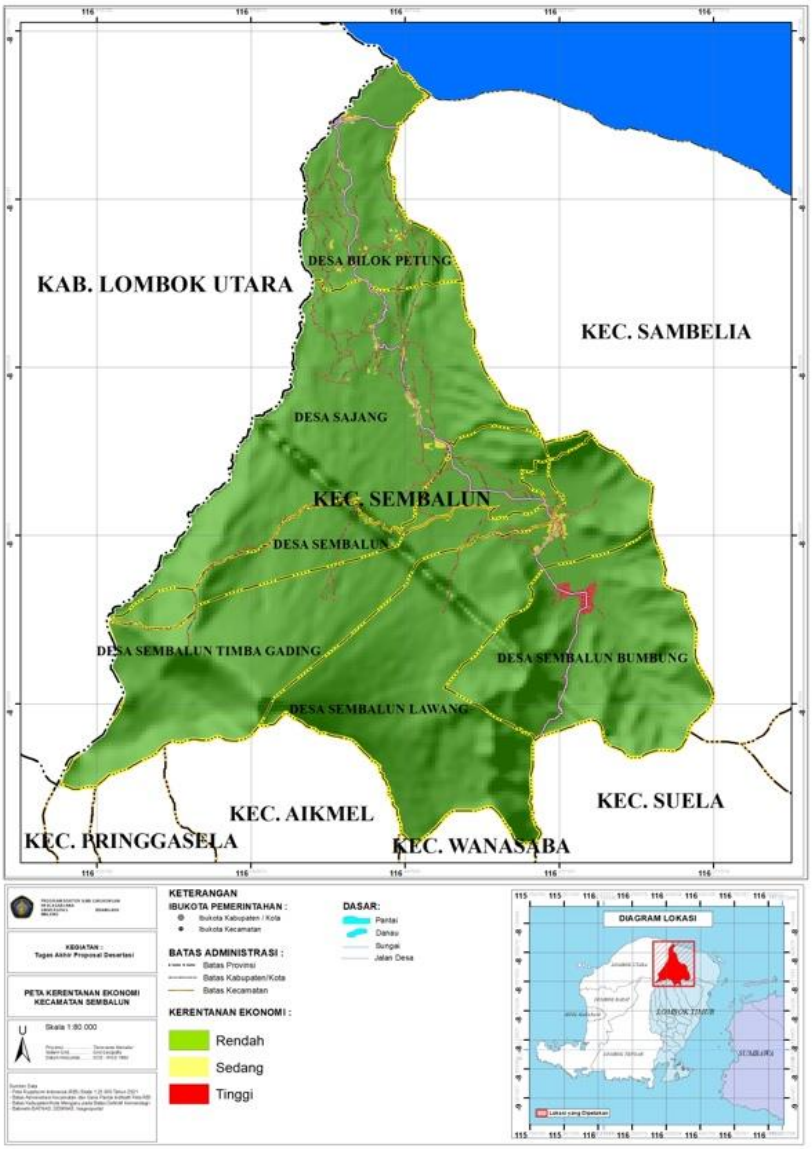

Figure 5 – Map of Economic Vulnerability (Source: result of Analysis, 2021)

Environmental vulnerability was identified through several indicators namely distribution of protected forests, natural forests, mangroves, shrubs, and swamps. The assessment of environmental vulnerability is detailed in Table 5.

Table 5 – Environmental Vulnerability of Sembalun District

Village	Area Environmental Vulnerability (Ha)			
	Low	Medium	High	Total
1. Sembalun	1.590	49	0	1.639
2. Sembalun Lawang	4.387	0	40	4.427
3. Sembalun Bumbung	2.911	53	0	2.964
4. Sembalun Timba Gading	3.239	0	0	3.239
5. Sajang	4.337	0	48	4.386
6. Bilok Petung	1.676	42	0	1.719

Source: Analysis Result, 2021.

The analysis revealed that Sembalun District has low environmental vulnerability.

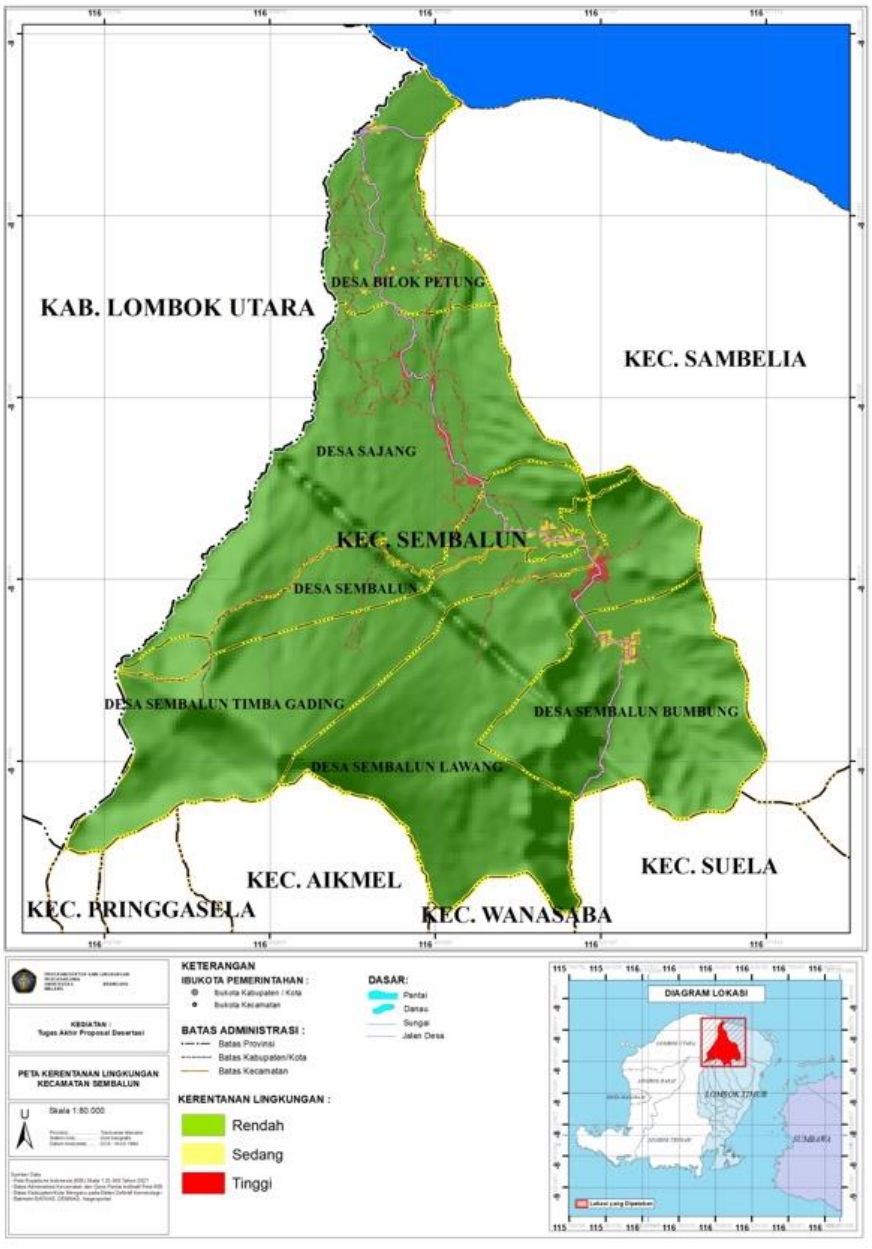

Figure 6 – Map of Environmental Vulnerability (Source: Analysis Result, 2021)

In Sembalun, Sembalun Bumbung, and Bilok Petung Villages, there are areas with medium environmental vulnerability with an area of 49 Ha, 53 Ha, and 42 Ha, respectively. Sembalun Lawang and Sajang villages have high environmental vulnerability with an area of 40 Ha and 48 Ha, respectively.

The four aspects of vulnerability were analyzed based on the extent that had been determined to find the total vulnerability of Sembalun District.

Table 6 – Total Vulnerability of Sembalun District

Village	Area Total Vulnerability (Ha)			
	Low	Medium	High	Total
1. Sembalun	1.590	49	0	1.639
2. Sembalun Lawang	4.387	0	40	4.427
3. Sembalun Bumbung	2.911	53	0	2.964
4. Sembalun Timba Gading	3.239	0	0	3.239
5. Sajang	4.337	0	48	4.386
6. Bilok Petung	1.676	42	0	1.719

Source: Analysis Result, 2021.

The highest vulnerability was found in Sembalun Lawang Village with an area of low vulnerability of 4.387 Ha and high vulnerability of 40 Ha.

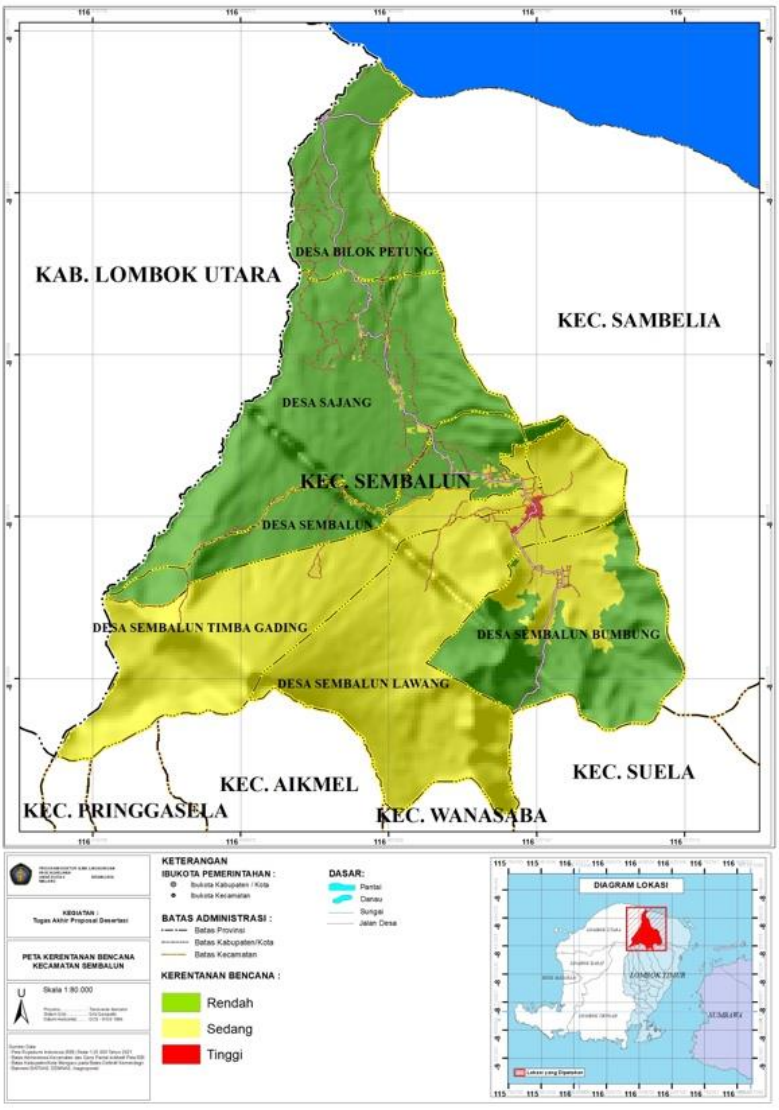

Figure 7 – Map of Total Vulnerability (Source: Analysis Result, 2021)

Capacity is all the resources owned by the community, whether they are individual, group, or managerial (UNISDR, 2005b). The analysis of the capacity value of Sembalun District was focused on several indicators, namely aspects of employment, aspects of poverty, aspects of misery against disasters, and aspects of quality of life/Human Development Index (HDI). Based on the result of the analysis, Sembalun District has low, medium, and high level of capacity. Sembalun Bumbung Village has high level of capacity.

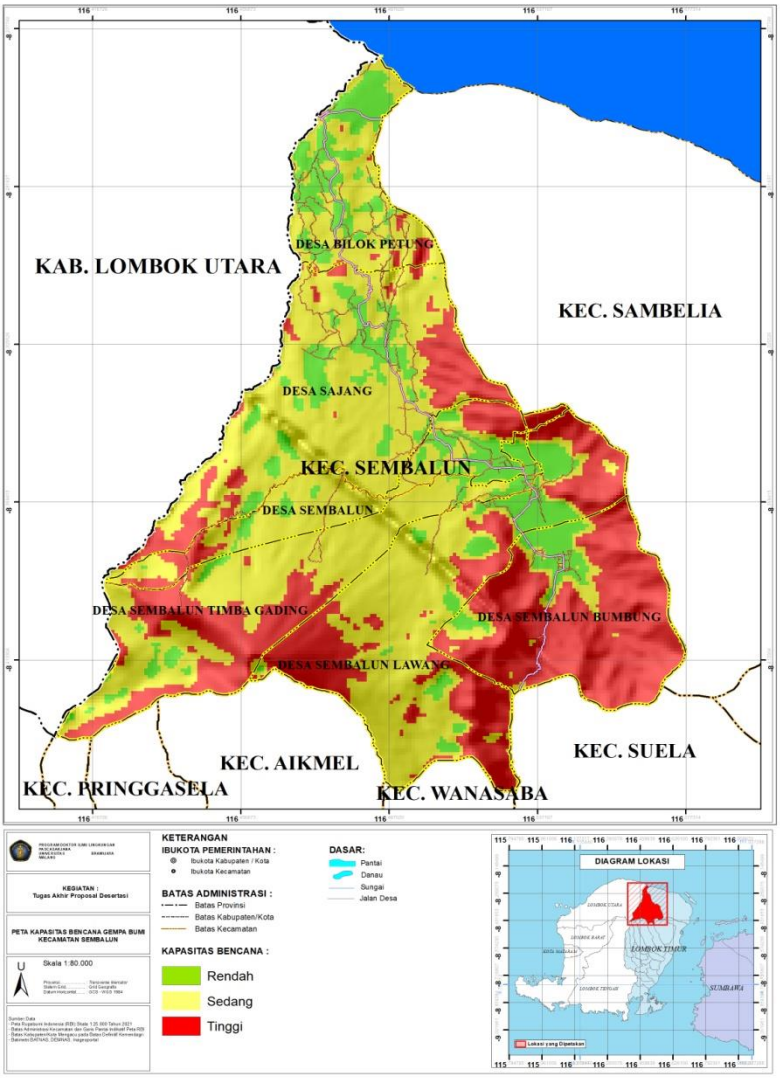

Figure 8 – Map of Earthquake Capacity (Source: Analysis Result, 2021)

Based on the assessment on earthquake hazard, earthquake vulnerability, and capacity to respond the earthquakes, Sembalun District has low, medium, and high risks. The areas in Sembalun District based on the earthquake risk are detailed in Table 7.

Table 7 – Earthquake Risks of Sembalun district

Village	Area Earthquake Risks (Ha)			
	Low	Medium	High	Total
1. Sembalun	1.294	291	54	1.638
2. Sembalun Lawang	1.705	2.183	503	4.390
3. Sembalun Bumbung	2.506	191	255	2.952
4. Sembalun Timba Gading	1.120	1.837	245	3.202
5. Sajang	3.672	618	0	4.290
6. Bilok Petung	1.008	671	19	1.698

Source: Analysis Result, 2021.

The highest risk area is in Sembalun Lawang Village with an area of low risk of 1.705 Ha, medium risk of 2.183 Ha and high risk of 503 Ha.

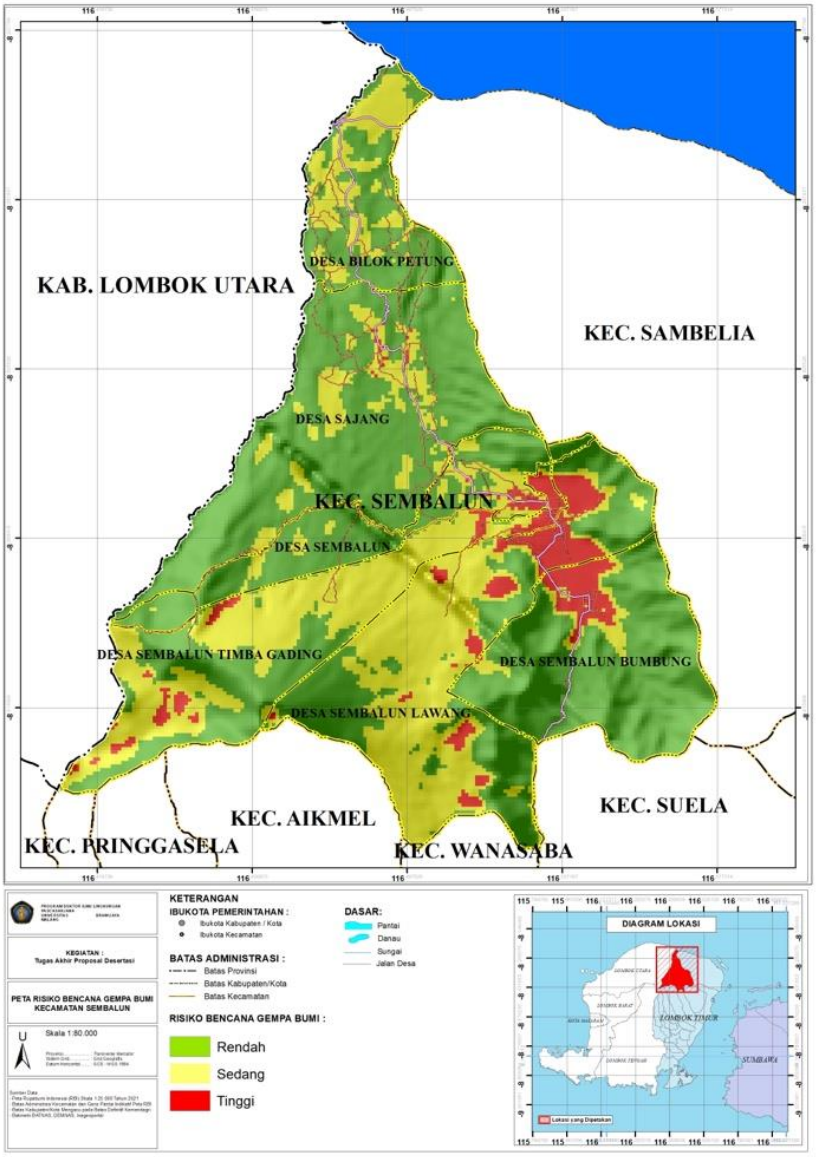

Figure 9 – The Map of Earthquake Risk (Source: Analysis Result, 2021)

Theoretically, the formulation of the criteria of sending and receiving areas was obtained through systematic review analysis of relevant theories and related research results. The systematic review was carried out to accommodate the results of a comprehensive related formulation.

The result of the synthesis became the input for the selected expert respondents. Later, it was validated its suitability with Sembalun District. The validation was conducted using Delphi mechanism which was proposed to selected respondents with analysis process and 2 iterations until it finally reached a consensus or agreement. The process of Delphi analysis in the research area is presented as follows:

At this stage, the researcher confirmed the influential variables as the results of literature review. Besides that, the researcher also asked the respondents about the possibility of criteria other than the variables in question. At this stage, it was found that there were 12 criteria that had reached a consensus, 2 criteria had not reached a consensus, and 1 new criterion. For the criteria that had not reached a consensus, a new criterion was proposed to be asked again to the respondents.

Criteria that had no effect were excluded in the second round because they were considered to be irrelevant in influencing the success of TDR implementation, especially in the research area. At this stage, 1 new criterion was found which was stated by one expert respondent. The result of this stage became the input for the next stage. The result of exploration on each respondent's opinion is presented in Table 9.

Table 9 – The Exploration of Delphi Round I

Area	No.	Criteria	Responses					Conclusion
			R1	R2	R3	R4	R5	
Sending	1	Areas whose resources or character need to be protected/preserved	A	A	A	A	A	The criterion reached a consensus: areas whose resources or character need to be protected/preserved.
	2	Areas with restricted development	A	A	A	A	A	The criterion reached a consensus: areas with restricted development.
	3	Areas with low building density	D	D	D	D	D	The criterion reached a consensus: excluded from the sending area criteria.
	4	Can be located in areas with high development demand, but with limited carrying capacity and capacity	A	A	A	A	A	The criterion reached a consensus: The areas with high development demand but with limited carrying capacity and capacity.
	5	The area without or with minimal infrastructure	D	D	D	D	D	The criterion reached a consensus: agreed to be excluded from the sending area criteria.
	6	Areas without transportation network	D	D	D	D	D	The criterion reached a consensus: agreed to be excluded from the sending area criteria.
	7	Areas that separate two or more contiguous protected areas	A	A	A	A	A	The criterion reached a consensus and it was agreed to be excluded from the sending area criteria because it has the same meaning with the criterion of areas whose resources or characters need to be protected/preserved.
Receiving	1	Areas with medium-high density with adequate infrastructure.	A	A	A	A	A	The criterion reached a consensus: areas with medium-high density with adequate infrastructure.
	2	Having carrying capacity and capacity to receive additional space intensity	A	A	A	A	A	The criterion reached a consensus: Having carrying capacity and capacity to receive additional space intensity
	3	Located in the area with high demand in development	A	D	A	D	D	The criterion had not reach consensus and it was suggested to be replaced with: areas which are developed based on spatial plan.
	4	New areas directed for residential and urban development	A	A	A	A	A	The criterion reached a consensus: new areas directed for residential and urban development.
	5	Adjacent to existing built-up area	A	A	A	A	A	The criterion reached a consensus: Adjacent to existing built-up area.
	6	Easy-to-use perceel (land lot) with low-cost infrastructure	A	A	D	D	D	The criterion had not reached a consensus and was suggested to be replaced by areas with adequate p*rasarana sarana utilitas* (utility infrastructure).
	7	Perceel with potential connection to public transport	A	A	A	A	A	The criterion reached a consensus: Perceel with potential connection to public transport
New Criteria								
Sending	1	Level of Damage caused by Earthquake Disaster	-	-	-	-	-	-
Receiving	2	The areas which are developed based on spacial plan.	-	-	-	-	-	-
	3	The areas with adequate *utilitas* (utility infrastructure).	-	-	-	-	-	-

Source: Analysis Result, 2021. Note: A – Agree; D – Disagree; - had not reach a consensus.

This stage was aimed at requestioning the 2 criteria that had not reach consensus and 1 new factor which was suggested by some related respondents in influencing the success of TDR program at the research location. Based on the respondents' answers in Delphi Round II, it was obtained that 2 criteria reached a consensus and 1 criterion had not reached a consensus. Regarding with the criterion that had not reach consensus, a new criterion was suggested to ask to the respondents. Exploration on the opinions of each respondent is presented in Table 10.

Table 10 – The exploration result of Delphi Round II

Area	No.	Criteria	Respondent's answers					Conclusion
			R1	R2	R3	R4	R5	
Sending	1	The level of damage caused to the area caused by earthquake	A	A	A	A	A	The criterion reached a consensus: The level of damage caused to the area caused by earthquake.
Receiving	1	The area which is developed based on spatial plan	A	D	D	A	A	The criterion had not reached a consensus and it was proposed to be replaced with a potential area based on spatial plan.
	2	Areas that have adequate Utility Infrastructure (*PSU*)	A	A	A	A	A	The criterion reached a consensus: areas that have adequate Utility Facilities (PSU).

Area	No.	Criteria	Respondents' answers					Conclusion
			R1	R2	R3	R4	R5	
Receiving	1	Potential areas based on spatial plan	A	A	A	A	A	The criterion had reached a consensus: potential areas based on spatial plan.

Source: Analysis Result, 2021. Note: A – Agree; D – Disagree; - had not reach a consensus.

Criteria for TDR Sending Areas based on earthquake disaster risk reduction in Sembalun District, include:

- the areas whose resources or characteristics need to be preserved/protected;
- areas with restricted development;
- areas with high development demand but its carrying capacity and capacity are limited;
- level of damage to the area caused by earthquake disaster.

Criteria for TDR receiving areas based on earthquake disaster risk reduction in Sembalun District include:

- areas with medium-high density with adequate support for disaster infrastructure;
- still have the carrying capacity and capacity to receive additional space intensity;
- new areas directed for residential and urban development;
- adjacent to the existing built-up zone;
- perceel with potential connection to public transport;
- areas with adequate utility infrastructure (*PSU*);
- potential areas which are in accordance to spatial plan.

After adjusting to the categories/requirements above, 3 villages were found suitable as the sending areas, namely Sembalun Lawang Village, Sembalun Bumbung, and Sembalun Timba Gading Village.

The results of formulation of sending and receiving areas can be alternative in determining the TDR policy formulation based on earthquake disaster risk reduction especially in Sembalun Village, East Lombok Regency. In the process, the exploration results on Delphi questionnaires produced criteria that were not found theoretically such as the level of damage caused by earthquakes, potential areas according to the spatial plan, and areas that have adequate *PSU*.

CONCLUSION

Land management mechanism such as TDR is starting to be widely used in several countries with different resources, technical capacity, and governance systems. Such conditions can be more complex to design and implement especially if land management capacity is poor. Research on the factors influencing the success of TDR by Rahadyan and Iskandar (2021) showed that determining the suitability of the sending and receiving areas is one of the success factors. It is said successful when it fulfills the regional terms and

conditions and there is a regional suitability analysis mechanism which is compatible with existing regional developments.

To implement TDR effectively as part of disaster risk management, the local governments must increase the capacity of existing land management. It can be done through combining TDR with municipal policy support tools, strengthening municipal and land administration capacities, and collaborating with real estate markets and supporting relevant community-based organizations.

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